

An aerial photograph of a wildfire in the Flint Hills of Kansas. The fire is a bright orange and yellow line moving across a dark, hilly landscape. The fire front is irregular and jagged, following the contours of the hills. The background is a dark, overcast sky.

# **A Prototype Decision Support System for Mitigating Rangeland Burning Impacts in the Kansas Flint Hills**

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**Department of Geography**  
**Kansas State University**

## Rangeland Fires:

*What are the ecological and air quality tradeoffs?*



**Fires increase rangeland productivity...**



**prevent woody invasion...**

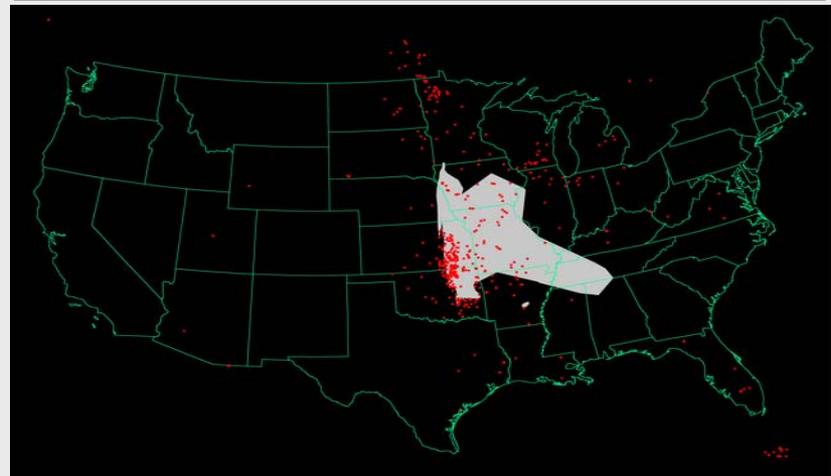
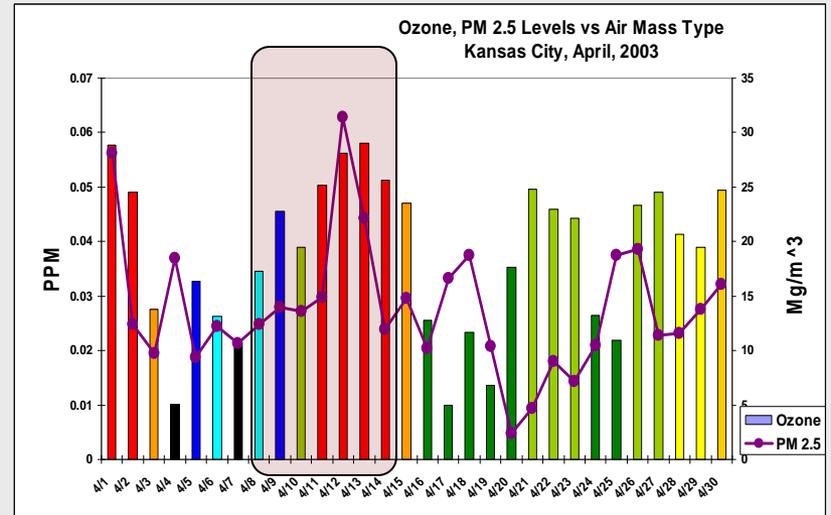


**and promote biodiversity**



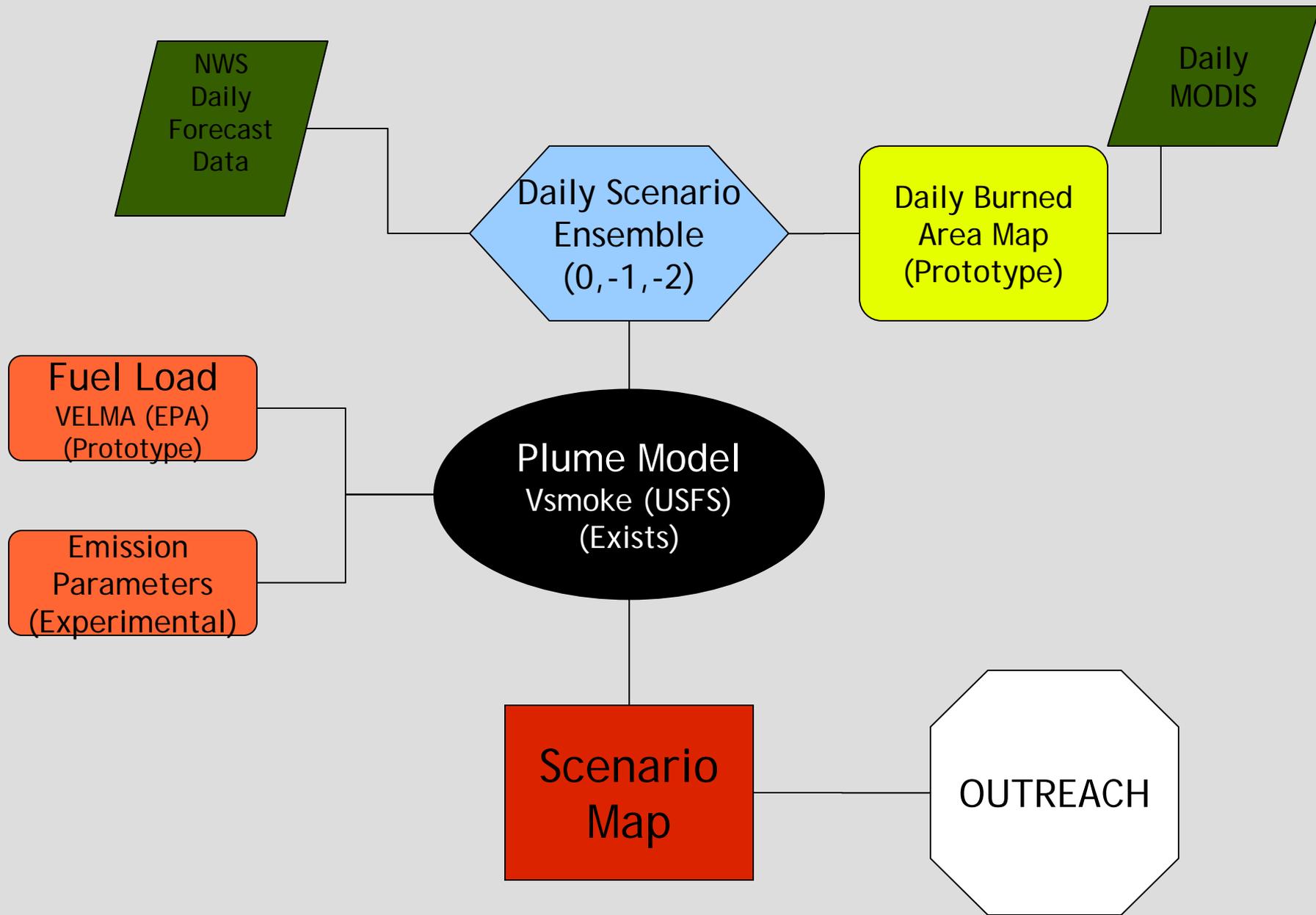
**but, are a source of particulates and ozone**

# Kansas Flint Hills



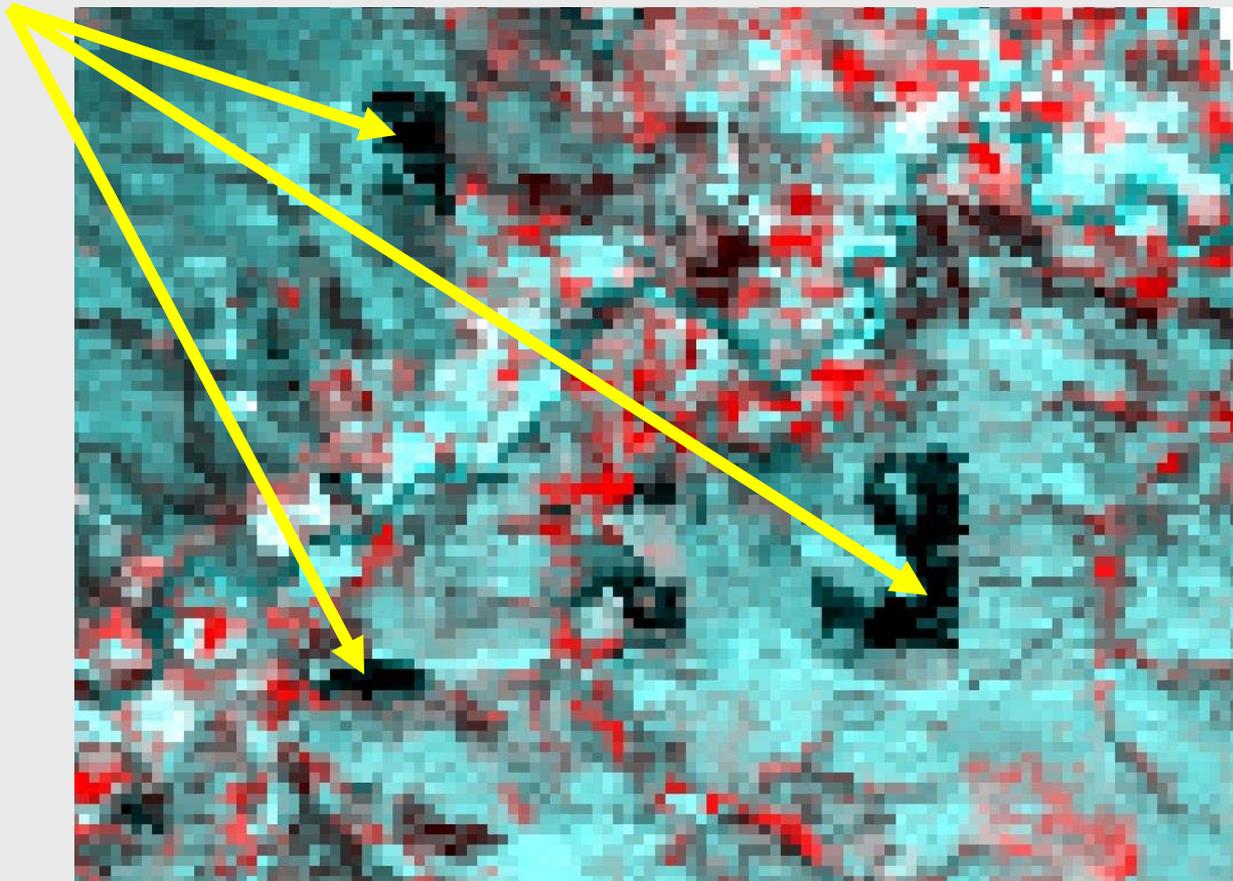
April 7-13, 2003

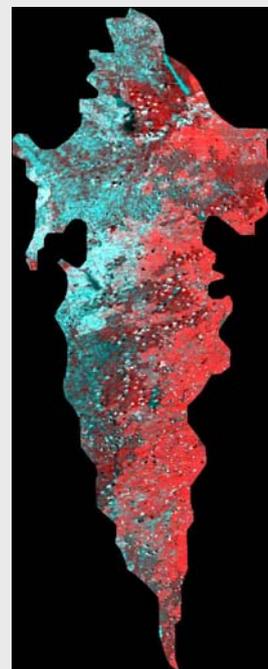
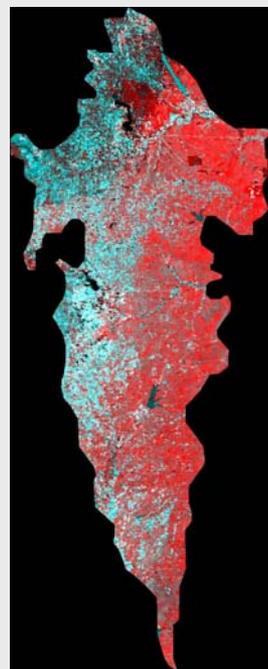
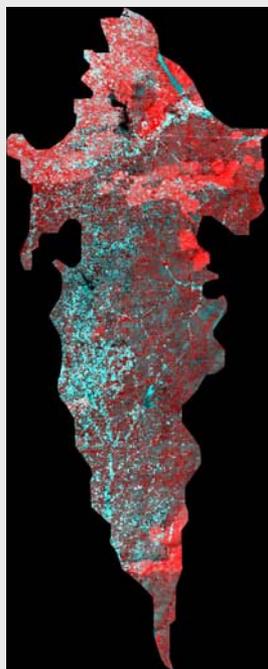
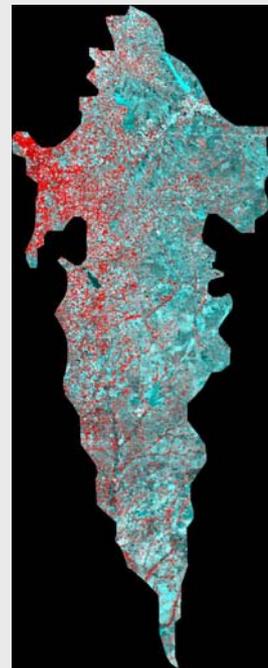
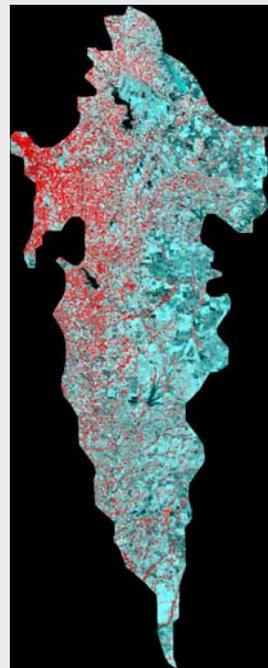
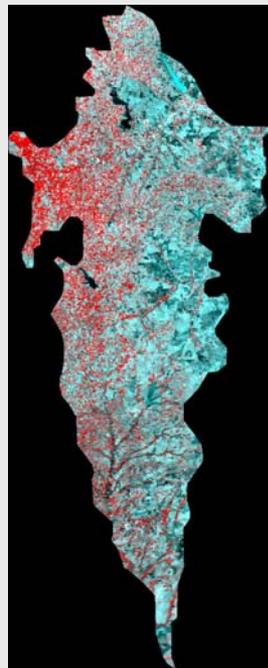
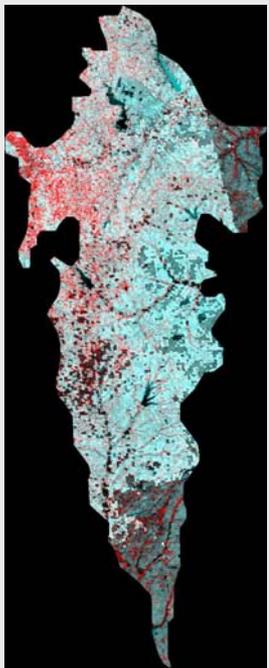
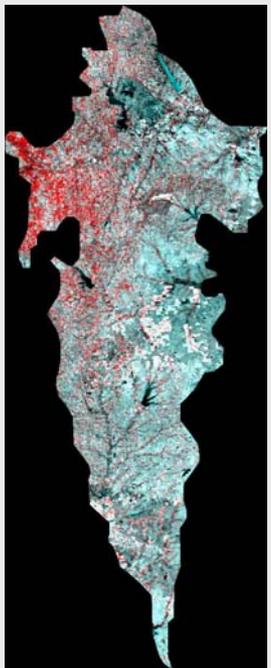
# Prototype Decision Support System



# Burn Mapping

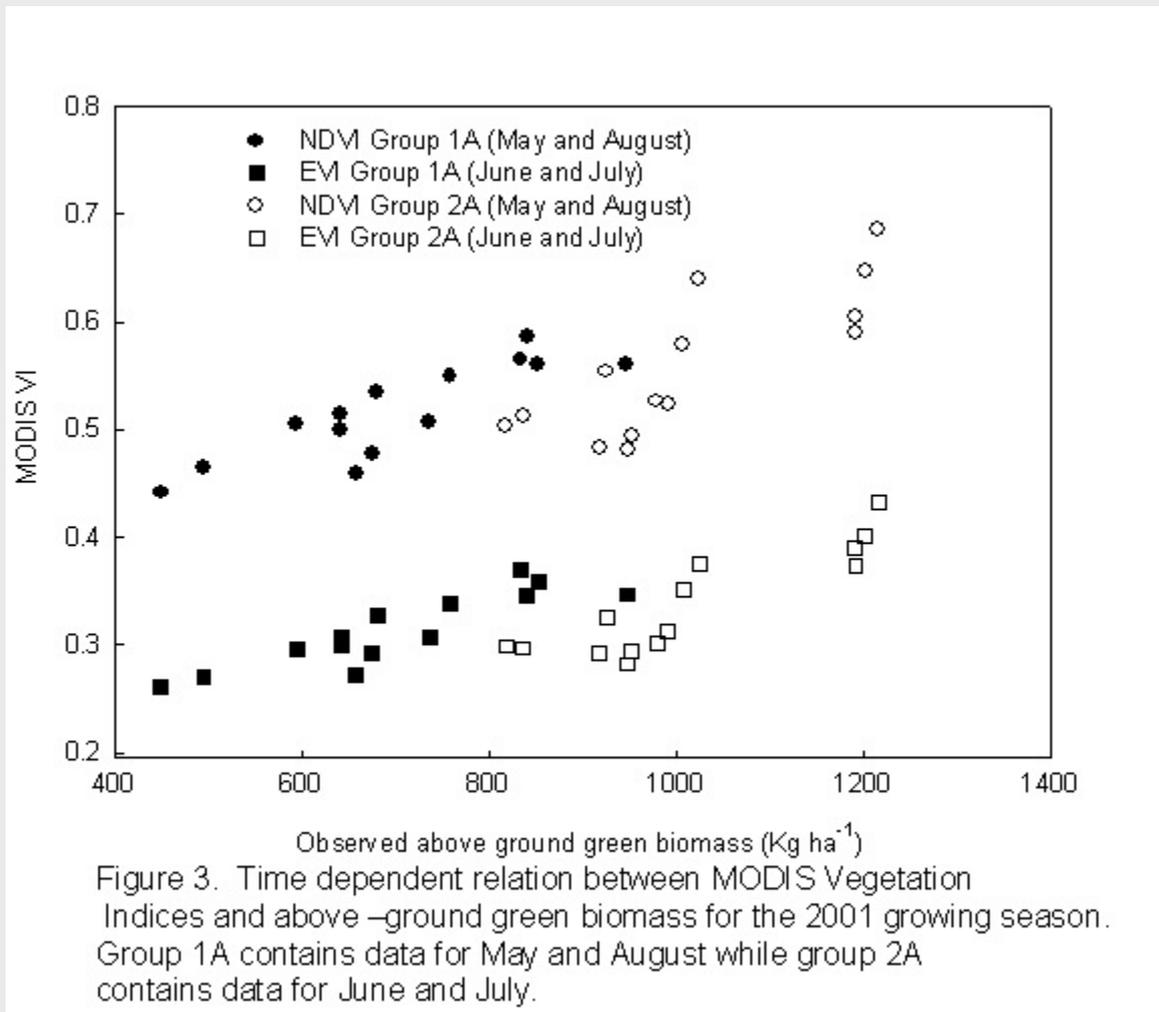
MODIS Data – 500 m resolution





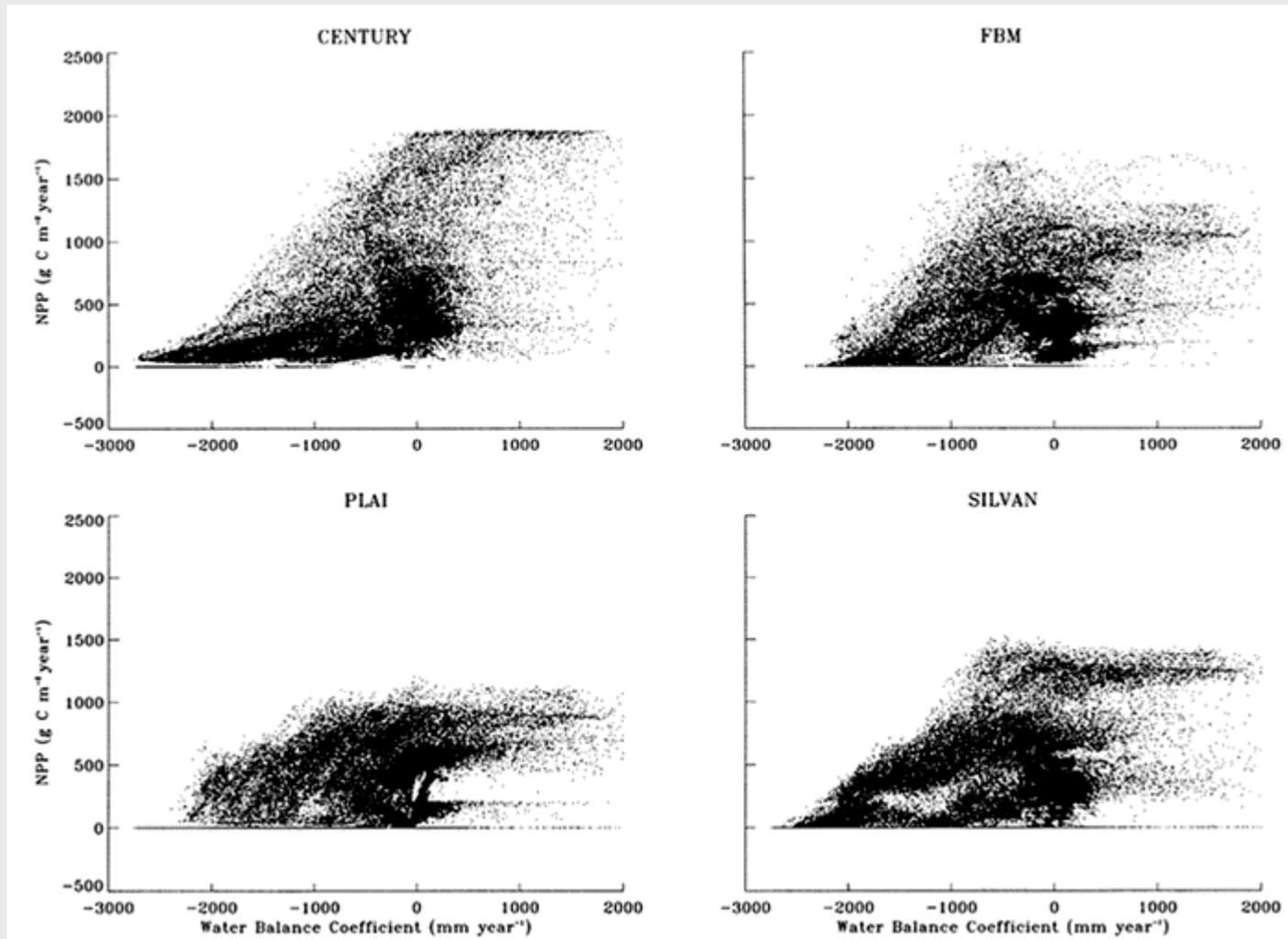
# Fuel Load Estimation

## Empirical Modeling with NDVI



# Biomass Estimation

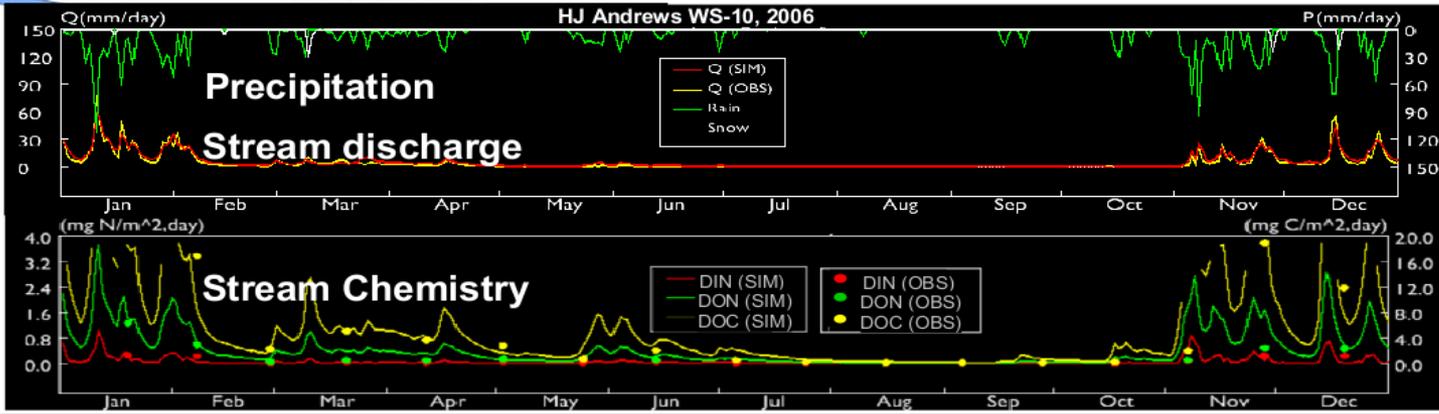
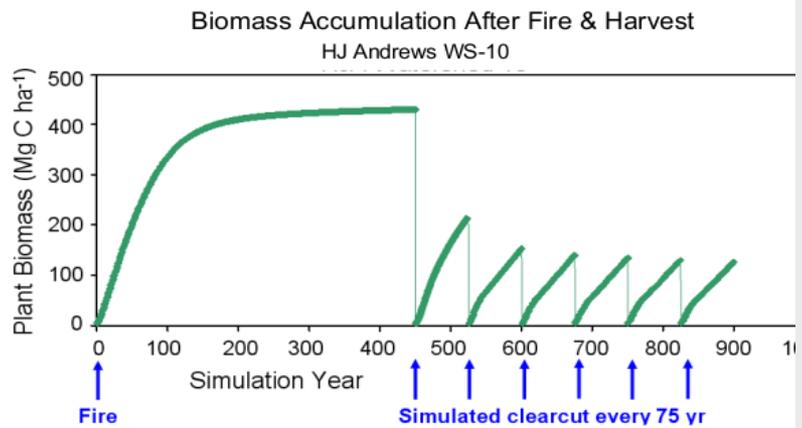
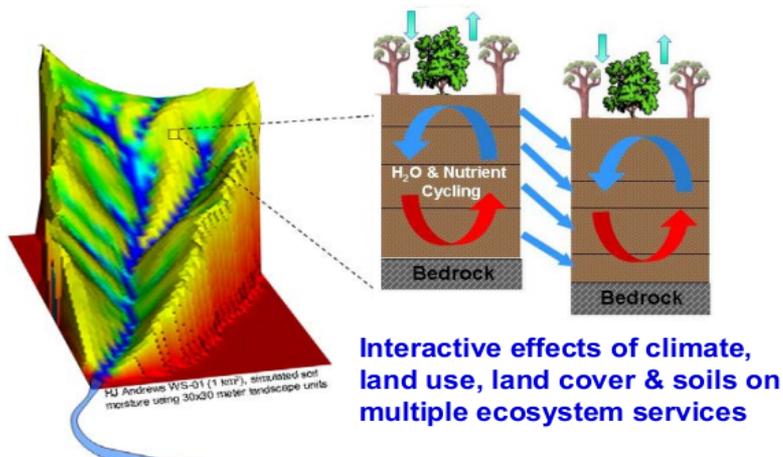
## Water Balance Modeling



# Fuel Load Modeling

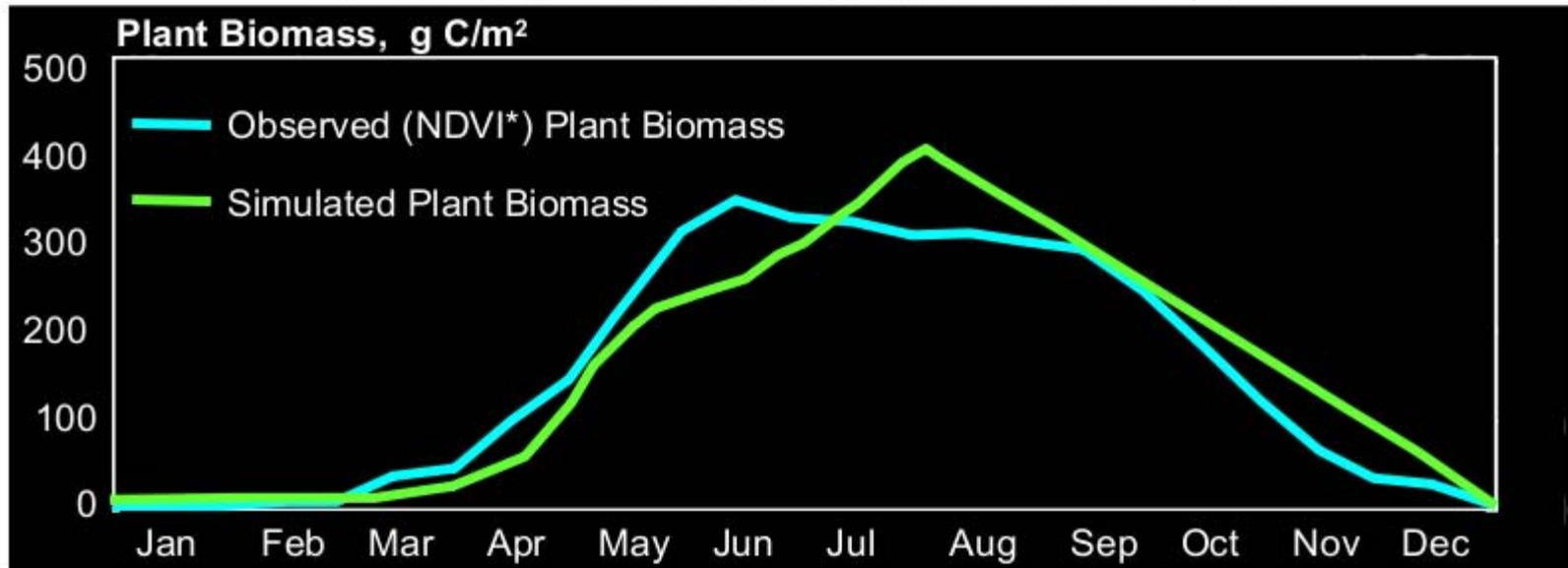
EPA Region 7 and ORD Western Ecology Center

## VELMA Ecohydrology Model *Linking Hydrological & Biogeochemical Processes in Watersheds*



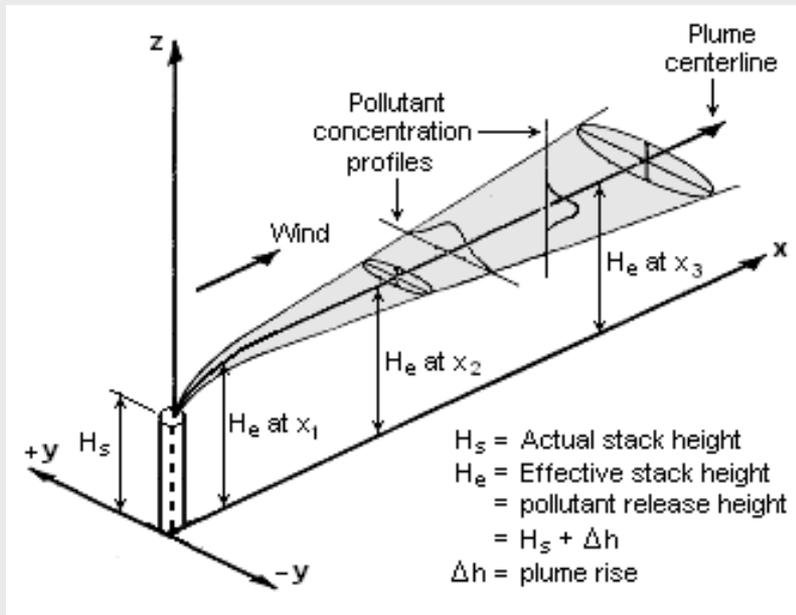
## VELMA Performance: Modeled plant biomass is well correlated with remote sensing data

11 km<sup>2</sup> Kings Creek Watershed, Konza Prairie, KS



\*For display purposes, data for Normalized Difference Vegetation Index (NDVI) were normalized with respect to plant biomass. NDVI data courtesy of Doug Goodin, Kansas State University.

# Smoke Diffusion Modeling: VSmoke



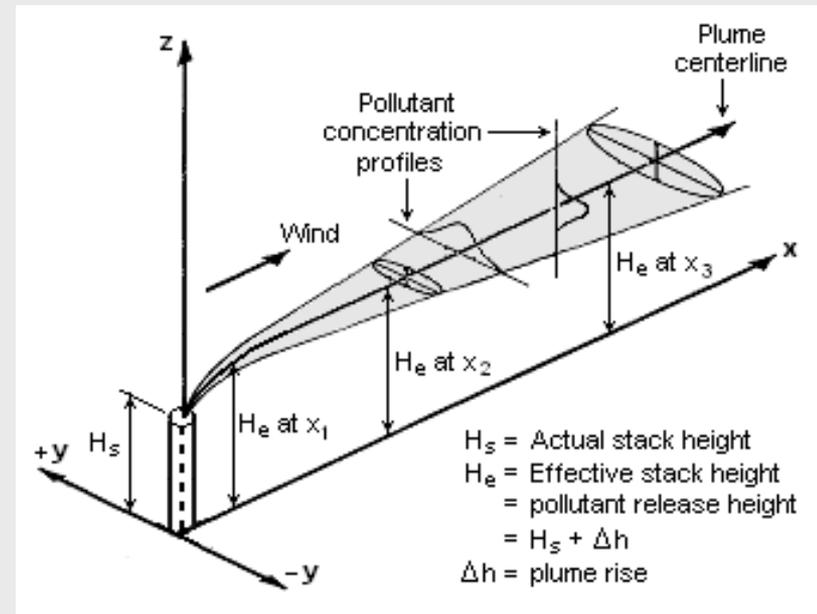
## Gaussian Plume Model

- Predicts downwind direction\size of dispersal plume
- Assumes steady-state
- Particulate only
- Relatively simple and fast – few computational limits

# Smoke Diffusion Modeling: VSmoke

$$C(x, y, z) = \frac{Q}{2 * \pi * u * \sigma_y * \sigma_z} * \exp\left(\frac{-y^2}{2 * \sigma_y^2}\right) * \left(\exp\left(\frac{-(z-h)^2}{2 * \sigma_z^2}\right) + \exp\left(\frac{-(z+h)^2}{2 * \sigma_z^2}\right)\right)$$

C= downwind concentration of  
particulates,  
Q=initial particulate concentration  
h=plume height  
u=wind speed  
 $\sigma_y, \sigma_z$  = standard deviation of normal  
plume in the x and y directions



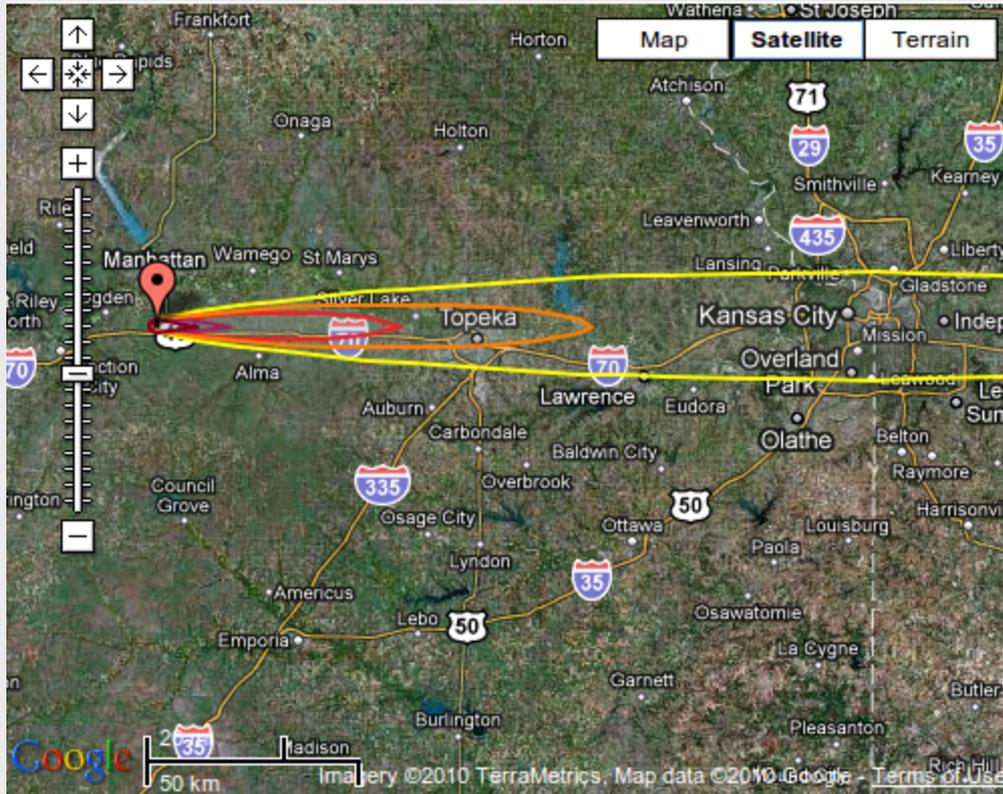
# Burn Parameters

Coconino National Forest, Northern Arizona



# VSmoke Output

<http://shrnc.ggy.uga.edu/maps/vsmoke.html#MYMAP>



## AQI

Levels of Health Concern	AQI Value	Hourly PM 2.5 Conc.	Meaning
Good	0 to 50	0 to 35	Air quality is considered satisfactory, and air pollution poses little or no risk.
Moderate	51 to 100	39 to 88	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101 to 150	89 to 138	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151 to 200	139 to 351	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201 to 300	352 to 526	Health alert: everyone may experience more serious health effects.
Hazardous	301 to 500	> 526	Health warnings of emergency conditions. The entire population is more likely to be affected.

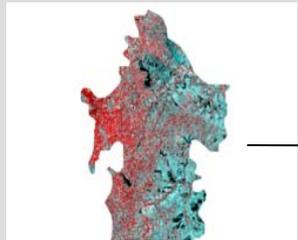
Note! AQI estimates depend On background PM values

# Implementation Scheme

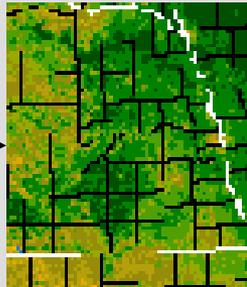
## Scenario-based



Weather Input  
Incorporating Range  
D0, D-1, D-2



Burned Area

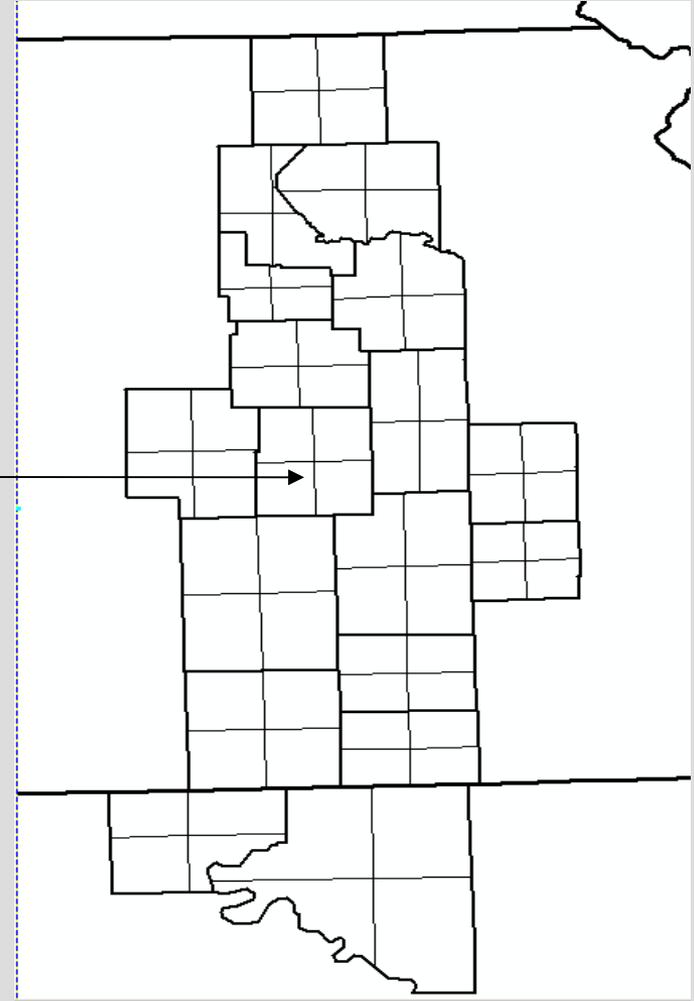


Fuel Load

### VSmoke Ensemble

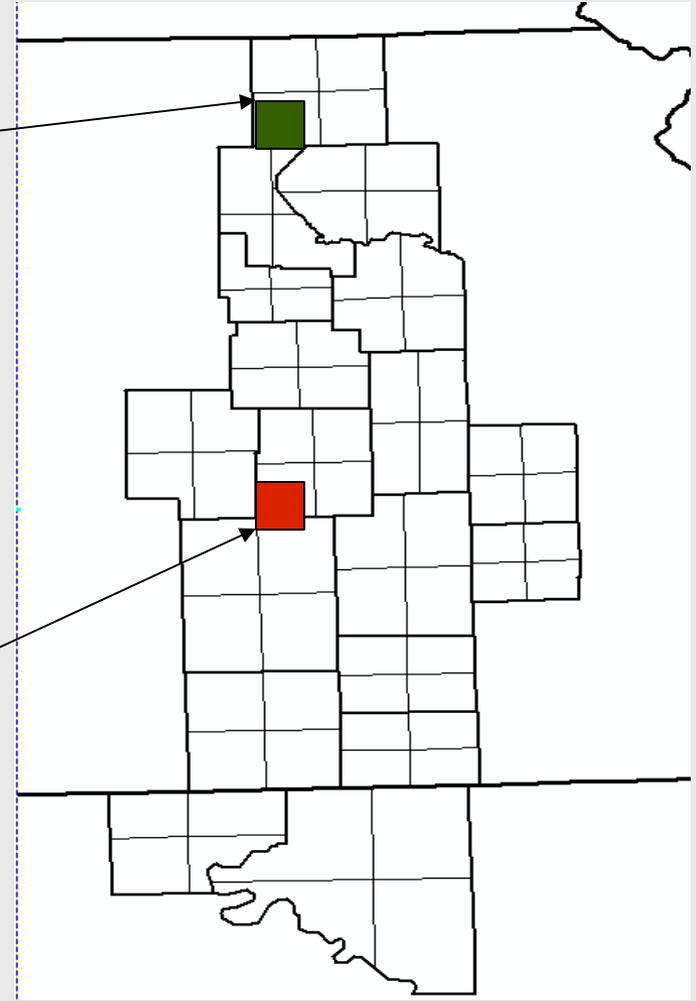
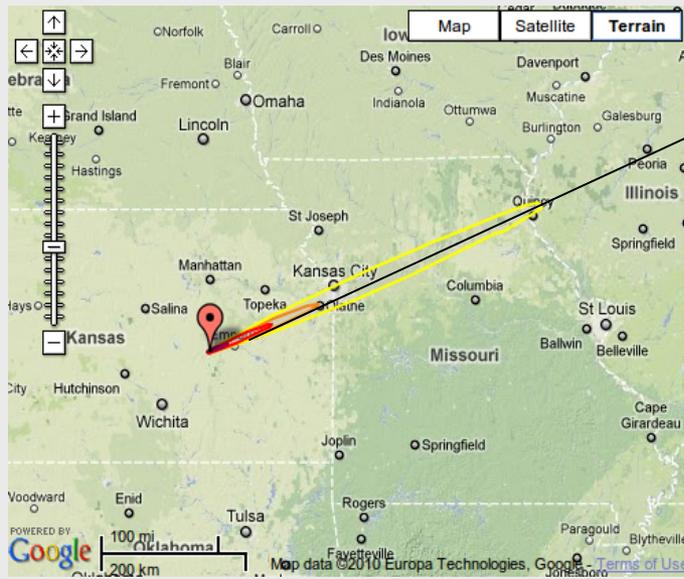
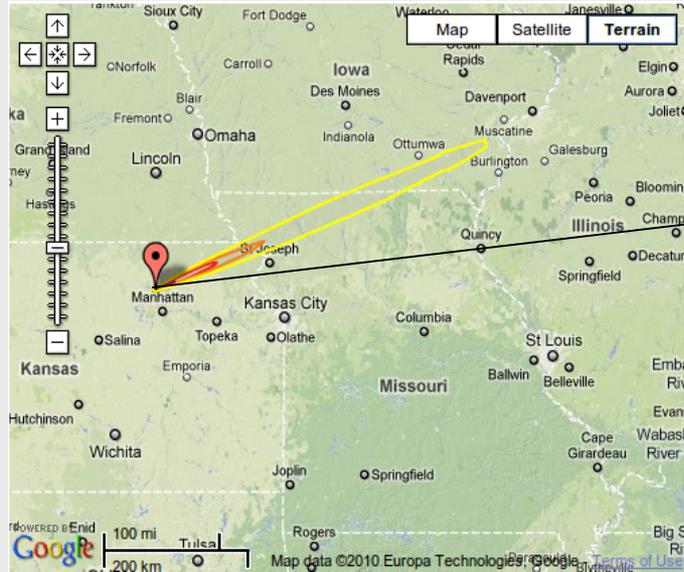
A series of model runs within boxes, varying:

- 1.) Input weather (constrained by forecast)
- 2.) Burned Area (constrained by daily burn maps)
3. Fire duration

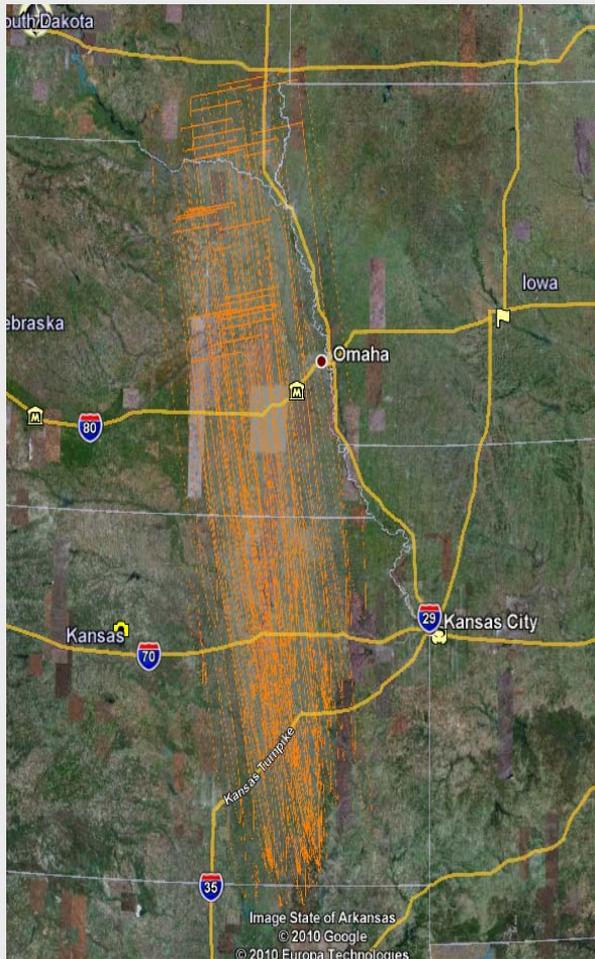


Flint Hills  
With 'Decision Boxes'

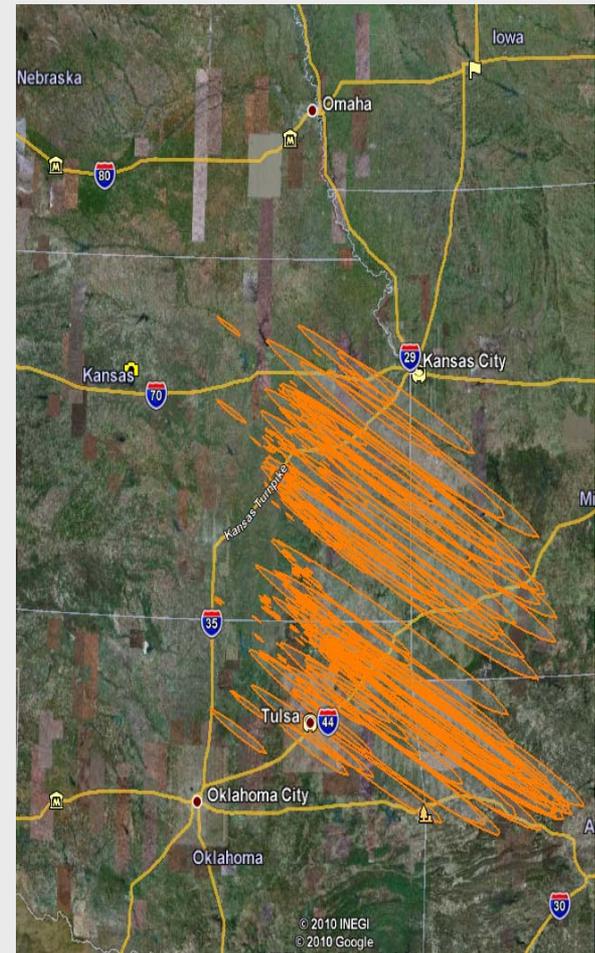
# Aggregate Result Of Vsmoke Ensemble Runs...



# Vsmoke Ensemble Output

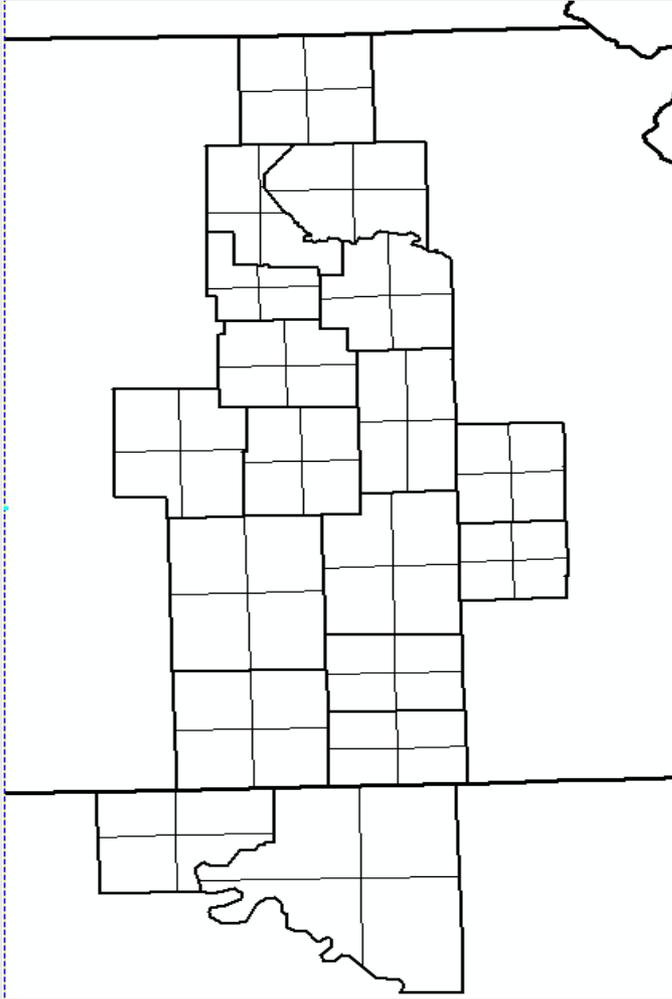


11 Apr 2003



12 Apr 2003

# Decision Support Products



- Level 1
  - 'Yes/No'
  - For D0, D-1, D-2
- Level 2
  - Probability Value
  - Confidence Range
  - For D0, D-1, D-2

# Education/Outreach

- Website(s)
- County Agents
- Print Media (Newspapers)
- E-Media (Radio\TV)
- Informal (Post in the cafe?)
- Smart Communications
  - Blackberry\Iphone Apps
  - GoogleEarth

# Model Decision Support System (mDSS)

<http://vsmoke.gfc.state.ga.us/Vsmoke/index.aspx>

<http://okfire.mesonet.org/>

<http://www.tallgrassontario.org/MNR/index.htm>

# Implementation Timeline

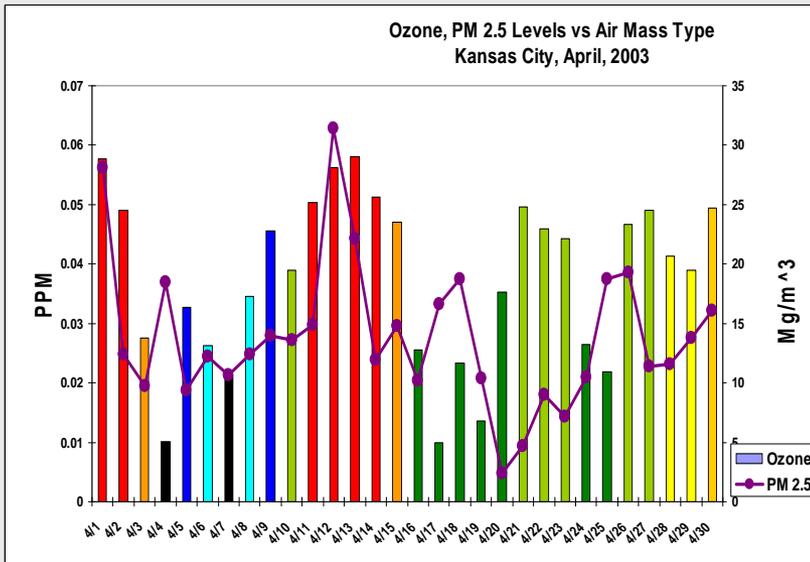
- PROTOTYPE: Spring, 2011
- Operational system: within 5 years
  - Personnel
  - Support

# Problems\Future Refinements

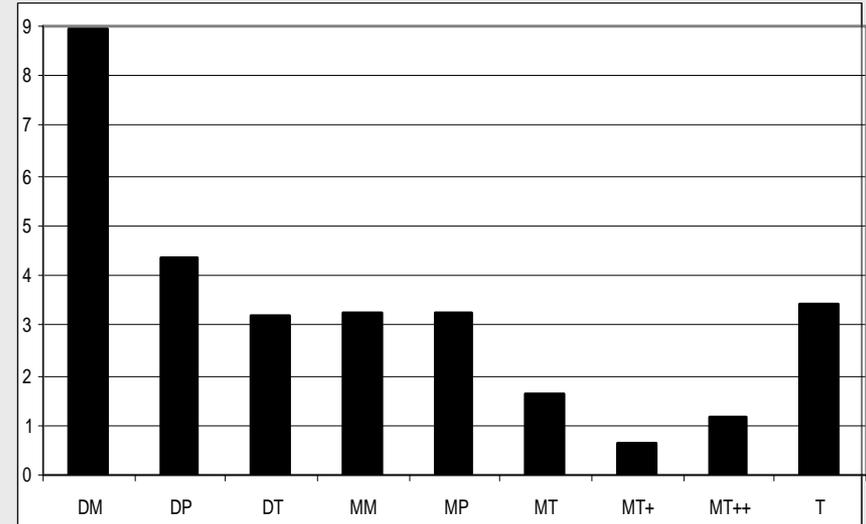
- Model output: PM vs. O3
- Scenario approach?
  - Multi-day plume travel
- What\Where are the “targets”
  - Greater KC Metro
  - Wichita
  - Topeka
  - Manhattan?
  - Lawrence?

# PM and Ozone

## A Climatological Approach



Pollutant Concentration



Air Mass Frequency

Analysis is in Progress...